

## Specification

MULTI-SHAFT SPINDLE HEAD OF MACHINE TOOL

## 5 Technical Field

The present invention relates to a multi-shaft spindle head of machine tool, wherein atomized cutting fluid is jetted from the tips of tools thereof.

## Description of the Prior Art

- 10 There exists a multi-shaft spindle head of machine tool, wherein a plurality of spindles having tools at the tips thereof in a same direction, the rear ends of cutting fluid feed passages formed as the inner holes of cutting fluid feed tubes installed in a non-rotatable manner at the rotating center parts of the spindles are allowed to communicate with a common closed chamber formed at the rear parts of
- 15 the spindles, and atomized cutting fluid fed into the common closed chamber is jetted from the tips of the tools through the cutting fluid passages. (For example, see Japanese Utility Model Gazette of No. 3060856.)

This multi-shaft spindle head is generally used so that a plurality of spindles cut a work piece at the same time.

- 20 The above-mentioned multi-shaft spindle head of machine tool does not have a means for changing a flow rate of atomized lubricant flowing from the common closed chamber into the cutting fluid feed passages. Accordingly, some spindles sometimes jet too much or too less lubricant from the tips of the tools thereof

- 25 Therefore, it is impossible to carry out higher quality cutting operation, and lubricant is sometimes fed in vain.

The invention aims to provide a multi-shaft spindle head of machine tool to settle such actual circumstances.

## 30 Summary of the Invention

To achieve the above-mentioned aim, in the present invention, a multi-shaft

spindle head of machine tool, wherein a plurality of spindles having tools at the tips thereof in a same direction, the rear ends of cutting fluid feed passages formed at the rotating center parts of the spindles are allowed to communicate with a common closed chamber formed at the rear parts of the spindles, atomized cutting fluid fed  
5 into the common closed chamber is jetted from the tips of the tools through the cutting fluid passages, and opening degree change means are formed to change the degrees of the opening at the rear end of the cutting feed passages.

According to this invention, the atomized cutting fluid fed into the common closed chamber passes through the cutting fluid feed passages in way of the opening  
10 degree change means, jetting from the tips of the tools. Accordingly, the jetting flow rates of cutting fluid of the spindles differ from one another in connection with the opening degrees determined by the opening degree change means.

Besides, the present invention is so constructed that a plurality of spindles having tools at the tips thereof in a same direction, the rear ends of cutting fluid feed  
15 passages formed as the inner holes of cutting fluid feed tubes installed in a non-rotatable manner at the rotating center parts of the spindles are allowed to communicate with a common closed chamber formed at the rear parts of the spindles, atomized cutting fluid fed into the common closed chamber is jetted from the tips of the tools through the cutting fluid passages, and opening degree change  
20 means are formed to change the degrees of the openings at the rear end of the cutting feed passages.

According to this, in addition to the above-mentioned effect, the following effect can be done. Since the cutting fluid feed passages are kept in non-rotatable manner regardless of rotations of the corresponding spindles, the atomized cutting  
25 fluid flowing in the cutting fluid feed passages is not influenced by the centrifugal force due to the rotations of the spindles. Therefore, liquefaction due to the centrifugal force is certainly prevented.

The above-mentioned inventions may be materialized as follows.

Each of the opening degree change means is provided with an inserted  
30 member with a taper part that is concentrically inserted into a cutting fluid feed passage from the opening of the rear end thereof. In this case, the taper part is

longitudinally displaced, and therefore, the degree of the opening at the rear end of the cutting fluid feed passage is changed in small or large. Besides, a circular passage is formed at the outer portion of the taper part in the opening of the rear end of the cutting fluid feed passage. The circular passage makes the atomized cutting fluid flowing symmetrically in the cutting fluid feed passage after passing therethrough to reduce inclination.

The inserted member is fixed to a wall surrounding the rear of the common closed chamber so as to be attached and removed from the outside thereof. According to this, the inserted member can be easily exchanged or removed, and therefore, the degree of the opening at the rear end of the cutting fluid feed passage can be easily changed within the broad range.

Besides, a longitudinal position of the inserted member is changed and adjusted from the outside of the wall surrounding the rear of the common closed chamber. According to this, the degree of the opening is to be easily adjusted by the opening degree exchanging means.

Moreover, a cutting fluid supply passage is provided to a thickness portion of the inserted member so as to extend from the front end face to the rear end face thereof. According to this, the cutting fluid supply passage supplies normal cutting fluid into the cutting fluid feed passage, and a part of the supplied normal cutting fluid is efficiently atomized through the atomized cutting fluid flowed in high-speed from the common closed chamber into the cutting fluid feed passage to be carried to the tip of the tool. Supply of the normal cutting fluid contributes to greatly change the flow rate of cutting fluid jetted from the tip of the tool at a stroke.

## Brief Description of the Drawings

Fig. 1 is a sectional view seen from the side of a multi-shaft spindle head of machine tool related to the present invention. Fig. 2 is a view taken on line X-X in Fig. 1.

Fig. 3 is an enlarged sectional view seen from the side of the multi-shaft spindle head, and Fig. 4 is a sectional view seen from the side of the rear end part of a spindle of the multi-shaft spindle head.

Fig. 5 is a sectional view seen from the side of a modification of the rear end part of the spindle, and Fig. 6 is a sectional view seen from the side of another modification thereof.

Fig. 7 is a front view showing a machining state of a work piece.

5 Fig. 8 is a side view of a multi-shaft spindle head related to the modification of the above-mentioned example.

### Preferred Embodiment of the Invention

The present invention will be explained particularly with reference to the  
10 drawings as follows.

In Fig. 1, Fig. 2 and Fig. 3, 1 is a bed, 2 is a moving table installed movably in a front direction f1 and a rear direction f2 through a guide rail 1a on the upper face of the bed 1, and 3 is a multi-shaft spindle head fixed on the upper face of the moving table 2.

15 The multi-shaft spindle head 3 is concretely constructed as follows.

That is, the multi-shaft spindle head 3 comprises a head frame 4 fixed on the moving table 2 and a spindle part 5 having a rear case frame 5a and a front case frame 5b on the front face of the frame 4.

The rear case frame 5a comprises a standing wall part 6 and a sidewall part  
20 7. And to the thickness part of the standing wall part 6, a feed passage 6a is formed to feed atomized cutting fluid from the outside. And to the rear face of the standing wall part 6, a surrounding wall 8a for forming a common closed chamber 8 is fixedly bolted. In this case, the feed passage 6a communicates with the inside of the closed chamber 8.

25 The front case frame 5b comprises a standing wall part 9 and a spindle case part 10. The standing wall part 9 is fixedly bolted to the rear case frame 5a. In front of the closed chamber 8, as shown in Fig. 3, a through hole 9a for inserting a spindle 11 therein is formed to each spindle 11.

30 The spindle case part 10 comprises a rectangular external wall part 12 for surrounding a plurality of spindles 11 and an intermediate wall part 13 for surrounding each spindle 11 thereinside.

On the front face of the external wall part 12, as shown in Fig. 3, a circular through hole a is formed so as to correspond to each spindle 11. And to the front face thereof, a front end cover 14 for being inserted into the spindle 11 is fixedly bolted.

5 Each of the spindles 11 comprises a forward large diameter part 11a and a rearward narrow diameter part 11b, rotatably supported at the fixed position on the front case frame 5b with a bearing 15 and a bearing 16 interfitted to the through hole a and the through hole 9a, respectively. A straight center hole b is formed to a center axial direction of each spindle 11, and the front part of the center hole b forms  
10 a double-level large diameter part b1.

Here, a member 17 for covering the front face of the front end cover 14 is fixed to each spindle 11, and an oil seal 18 is interfitted into the front end cover 14.

A tool support cylindrical member 19 is fixedly interfitted to the fixed position of the large diameter part b1 of the center hole b, and a tool 20 is arranged  
15 into the cylindrical member 19. Then, passage holes c1, c2 are respectively formed to the center axial directions of the center parts of the cylindrical member 19 and the tool 20.

Into the center hole b of each spindle 11, a straight cutting fluid feed tube 21 having a narrower diameter than the center hole b is provided concentrically  
20 therewith. The rear end of the feed tube 21 is arranged into a hole 6b formed to the standing wall part 6 of the rear case frame 5a, fixed to the standing wall part 6 through a binding part 22 or a packing. A cutting fluid feed passage 21a of an inner hole of the feed tube 21 airtightly communicates with the inside of the closed chamber 8. The front end of the feed tube 21 is almost airtightly inserted into the  
25 passage hole c1 of the cylindrical member 19 through the rear end of the large diameter part b1 of the center hole b.

In this case, a roller bearing 23 is provided between the front end of the feed tube 21 and the large diameter part 11a of the spindle 11, contributing to smooth rotation of the spindle 11 so as not to be prevented by the feed tube 21.

30 The spindles 11 are respectively driven by a spindle driving motor 24 installed on the head frame 4 in Fig. 1.

That is, a driving shaft 25 connecting with an output axis of the motor 24 is arranged in a gear chamber 26 surrounded by the frames 5a, 5b rotatably at the fixed position, and a driving gear 27 is formed to the tip of the driving shaft 25. On the other hand, in the gear chamber 26, a driven gear 28 is fixed to the rear end of the spindle 11, interlocked and connected with the driving gear 27 by a gear row comprising a plurality of intermediate gears 29.

In front of the multi-shaft spindle head 3, a fixing table for work piece 30 is provided so as to form constant configuration against the bed 1. In this case, a surrounding frame member 31 is fixed around a face for supporting work piece 30a thereof

A cover device 32 is installed so as to extend in the front direction f1 and the rear direction f2, closely abutted to the surrounding frame member 31 to surround a work piece and the front part of the multi-shaft spindle head 3 in which the underside only is opened.

A hopper guide passage 33 is to guide cutting chips and cutting fluid, arranged so as to cover the underside of the cover device 32. A guide device 34 is to guide cutting fluid dropped from the hopper guide passage 33 into a desirable portion.

In Fig. 3, 35 is a cutting fluid atomizing device for generating atomized cutting fluid, comprising a compressed air feed tube 36, a filter 37a, a pressure adjuster 37b, an atomizing device 37c and a cutting fluid transmitting tube 38. The transmitting tube 38 is communicated with the feed passage 6a through a pipeline 39. Besides, in the middle of the transmitting tube 38, an electromagnetic valve 40 is provided so as to timely open and close through a not-illustrated control unit.

Next, characterful structure of the present invention will be explained with reference to Figs. 4 to 6.

As shown in Fig. 4, to the rear part of the feed passage 21a, an opening degree change means 41 is formed to change the degree of an opening at the rear end of the feed passage 21a. The opening degree change means 41 comprises an inserted member 42, which has a taper part 42a inserted from the opening at the rear end of the feed passage 21a concentrically therein.

As shown in Fig. 4, the inserted member 42 whose rear part is made a male thread part 42b, and besides, a rotational input part 42c for giving torque throughout with a spanner engaged is formed at the rear end of the thread part 42b.

On the other hand, a through hole e comprising a longitudinal female thread part e1 and a seal part e2 is formed to the surrounding wall 8a whose portion is opposite to a taper hole part d forming an opening at the rear end of the feed passage 21a. The inserted member 42 is fixed through the female thread part e1. In installing the inserted member 42, the taper part 42a is inserted from the rear of the surrounding wall 8a into the closed chamber 8 through the through hole e, continuously, a part of thereof is inserted in the rear end of the feed passage 21a. Then, the male thread part 42b is screwed in the female thread part e1 by a desirable length, and thereafter, a lock nut 43 is screwed into the male thread part 42b to joint the male thread part 42b and the female thread part e1. In this case, the taper part 42a is supported almost concentrically with the taper hole part d.

The degree of the opening at the taper hole part d is adjusted by displacing the longitudinal position of the taper part 42a against the feed passage 21a as rotating the male thread part 42b. Concretely, the male thread part 42b is displaced forward to the female thread part e1, thereby gradually diminishing the width of a circular passage g formed between the feed passage 21a and the taper part 42a. Conversely, the male thread part 42b is displaced rearward to the female thread part e1, thereby gradually increasing the width.

The inserted member 42 may be transformed into an inserted member 42A as shown in Fig. 5, namely, having a cutting fluid supply passage 42d extending from the front end face h1 of the thickness part thereof to the rear end face h2. And to the supply passage 42d, a normal cutting fluid feed tube 45 elongated from a normal cutting fluid feed device 44 is connected.

The cutting fluid feed device 44 comprises a cutting fluid tank 46, a reciprocating pump 48, and an air pressure reciprocating cylinder device 49 and a magnetic valve 51. Here, the tank 46 is to store normal cutting fluid, and the pump 48 sucks and discharges the fixed amount of the normal cutting fluid from the tank 46 into the supply passage 42d through a suction tube 47, repeatedly. The cylinder

device 49 is to reciprocally drive the pump 48. The magnetic valve 51 is provided to a compressed air feed tube 50 connected to the cylinder device 49 to timely open and close through a not-illustrated control device. The normal cutting fluid is fed into the feed tube 21 through the magnetic valve 51. Besides, an operational  
 5 velocity of the pump 48 is changed in accordance with an open and close velocity of the magnetic valve 51 to change the flow rate of the normal cutting fluid.

Besides, the inserted member 42 may be transformed to an inserted member 42B as shown in Fig. 6. That is, therein, the male thread part 42b forms a round bar part 42e and a flange part 42f is formed to the rear end thereof. The  
 10 inserted member 42B is so fixed that a portion for the female tread part e1 of the surrounding wall 8a forms a simple circular hole part e3, the taper part 42a is inserted from the rear side of the hole part e3 into the closed chamber 8 and the rear end part of the feed tube 21, the round bar part 42e is arranged in the hole part e3, the flange part 42f is abutted on the outer face of the surrounding wall 8a, and the  
 15 flange part 42f is fastened to the surrounding wall 8a with bolts

The degree of the opening d at the rear end of the feed passage 21a is adjusted by changing the longitudinal position of the taper part 42a against the feed passage 21a so as to change the thickness of a spacer 52 in which is installed between the outer face of the surrounding wall 8a and the flange part 42f.  
 20 Concretely, the thickness of the spacer 52 is reduced, thereby reducing the width of a circular passage g formed between the feed passage 21a and the taper part 42a. Conversely, the thickness thereof is enlarged, thereby enlarging the width thereof.

A using example and its operation of the above-mentioned embodiment will be explained as follows.

25 Fig. 7 is a plane view of a work piece in a machining manner. As shown in Fig. 7, four comparatively shallow holes m1 are bored on the upside front face of a rectangular work piece w, and four comparatively deep holes m2 are bored on the downside front face thereof. Empirically or from the result of previous experimental machining, it is identified that the flow rate of the cutting fluid for  
 30 machining the shallow holes m1 is preferably made about 10 ml per an hour and that of the deep holes m2 is preferably made about 50 ml per an hour.



In this case, a worker unfastens the lock nut 43 and gives rotational power to the rotation-input part 42c with a spanner to rotate the inserted member 42, as necessary. According to this, the longitudinal position of the inserted member 42 is adjusted so that the flow rate of the cutting fluid from the tool 20 is made the fixed  
 5 flow rate correspondent to the machining holes m1, m2. And the lock nut 43 is fastened so as to keep the longitudinal position.

On the other hand, the moving table 2 is displaced from the position of Fig.1 to the rear direction f2, and the work piece w is fixed on the supporting face 30a of the fixing table 30.

10 Next, the motor 24 is operated. According to this, rotation of the motor 24 is communicated with the spindles 11 through the gears 27, 29, 28, and the spindles 11 are guided by the bearings 15, 16 to rotate smoothly. During this rotation, since the feed tubes 21 are fixed on the standing wall part 6, they are kept in a non-rotatable manner.

15 Then, the magnetic valve 40 is opened with relation to the operation of the motor 24. According to this, the compressed air fed from the compressed air feed tube 36 flows in the atomizing device 37c to generate atomized cutting fluid on atomizer principle.

Thus generated atomized cutting fluid arrives in the closed chamber 8  
 20 through the feed passage 6a, being fed therefrom into the feed tubes 21 through the taper hole parts d of the rear end parts thereof, continuously flowing out toward the front direction f1. In this case, the degrees of the openings of the taper hole parts d are suitably adjusted by the inserted members 42 of the opening degree changing means 41. Since the feed tube 21 is non-rotatably kept, the atomized cutting fluid  
 25 forwardly flowing in the feed tube 21 is not affected by centrifugal force on rotation even if the spindles 11 rotate in high speed. Accordingly, in the feed tube 21, liquefaction is not caused by the centrifugal force, and a component separating phenomena is caused by differences between specific gravities of components thereof, thereby keeping the atomized cutting fluid in equally distributed manner.

30 The cutting fluid in the feed tube 21 flows out from the front end thereof, arriving to the passage hole c1 of the cylindrical member 19, continuously jetting

from the tip of the tool 20 through the passage hole c2 thereof. Under this condition, the moving table 2 is displaced to the front f1. When the displacement is over the fixed value, the tip of the tool 20 reaches the work piece w to machine it. During this machining, since the fixed amount of the atomized cutting fluid jets from the tip of the tool 20 correspondingly to the holes m1, m2, machining portion of the tool 20 turns to be equally-effectively lubricated.

In the above-mentioned example, when further deeply machining only a part of the holes m1, m2, the flow rate of the cutting fluid requires to be broadly increased correspondingly to the holes m1, m2, for example, made about 150 ml per an hour. In this case, the inserted member 42 corresponding to the holes m1, m2 is exchanged to the inserted member 42A shown in Fig. 5.

Then, in connection with the operation of the magnetic valve 40 in the above-mentioned example, a different magnetic valve 51 is also operated in a suitable speed. According to this, the atomized cutting fluid fed into the closed chamber 8 flows into the feed tube 21 through the circular passage g. And at the same time, the fixed flow rate of normal cutting fluid in the tank 46 is fed into the supply passage 42d through the pump 48 to be supplied from the opening of the front end face h1 of the inserted member 42A in the feed tube 21 in a normal liquid manner.

Accordingly, the flow rate of the cutting fluid flowing in the feed tube 21 becomes for example 150 ml per an hour. The cutting fluid supplied from the supply passage 42d is refined and equally dispersed by a flow energy of the atomized cutting fluid symmetrically-powerfully flowing from the circular passage g into the feed tube 21. And thereafter, it stably jets from the tip of the tool 20 with the atomized cutting fluid flowed from the circular passage g.

When the cutting fluid is supplied from the passage 42d, since it is not in atomized manner but in normal liquid manner, the flow rate thereof is variously changed to greatly change the flow rate of the cutting fluid jetted from the tip of the tool 20. Accordingly, even if the flow rate of the cutting fluid fed through the circular passage g is about 50-60 ml per an hour, that of the cutting fluid jetted from the tip of the tool 20 is easily made about 500-600 ml per an hour.

The inserted member 42 in the above-mentioned example may be changed to an inserted member 42B shown in Fig. 6. In this case, since the inserted member 42B is positioned by the round bar part 42e and the circular hole part e3, the position is exactly maintained in comparison with the inserted members 42, 42A positioned by the male thread part 42b and the female thread part e1. Accordingly, the concentricity between the taper part 42a of the inserted member 42B and the taper hole part d improves, thereby more equalizing and stabilizing the flow rate of the atomized cutting fluid in the feed tube 21.

The above-mentioned example can be modified as shown in Fig. 8. Here, Fig. 8 is a side view of a multi-shaft spindle head related to the modification of the above-mentioned example.

In the modification, the feed tube 21 is not provided. Instead of it, a narrow diameter shaft part 53 is rearward extended from the rear end of the spindle 11 to arrange the rear end thereof into the closed chamber 8 through the through hole 6a of the standing wall part 6. Besides, the center hole b of the spindle 11 is extended to the rear end of the narrow diameter shaft part 53. Further, a seal member 54 for keeping a space between the inside face of the through hole 6a and the outer face of the narrow diameter shaft part 53 in airtight manner under the condition that the rotation of the narrow diameter shaft part 53 is permitted.

The spindle 11 and the center hole b of the narrow diameter shaft part 53 are used as the feed passage 21a, and an opening degree changing means 41 is formed to the tip of the passage 21a equally with the above-mentioned example. The multi-shaft spindle head is so constructed that the atomized cutting fluid fed into the closed chamber 8 jets from the tip of the tool 20 through the feed passage 21a.

In the modification, since the feed passage 21a rotates integrally with the rotating spindle 11, centrifugal force affects the atomized cutting fluid flowing in the feed passage 21a to cause liquefaction. However, as long as the spindle 11 is not rotated in high speed, the liquefaction is within the permitted range.

## INDUSTRIAL APPLICABILITY

According to the present invention, the following effects can be made.

According to feeding the atomized cutting fluid having the fixed pressure into the common closed chamber, the cutting fluid can be equally jetted from the tips of the tools of the spindles, thereby enabling each spindle to machine high-accurately and efficiently.

Besides, according to feeding the atomized cutting fluid having the fixed pressure from the non-rotatable cutting fluid feed tube into the common closed chamber, the cutting fluid can be equally jetted from the tips of the tools of the spindles. In addition, even if the spindles are rotated in high speed, the atomized cutting fluid flowing therein can be prevented from fluorination. Therefore, the spindles can respectively machine high accurately and efficiently.

Moreover, according to displacing the position of the taper part in the longitudinal direction, the degree of the opening at the rear end of the cutting fluid feed passage can be changed to small or large. In addition, in the opening at the rear end of the cutting fluid passage, the circular passage is formed on the outer portion of the taper part to make the flow of the atomized cutting fluid therein fair.

Furthermore, the inserted member can be easily exchanged and removed, and the broad change in the degree of the opening at the rear end of the cutting fluid feed passage can be easily performed.

Beside, changing and adjusting of the degree of the opening at the rear end of the cutting fluid feed passage by the opening degree change device can be easily performed.

Moreover, the normal cutting fluid can be supplied from the cutting fluid supply passage into the cutting fluid feed passage, and a part of the supplied normal cutting fluid can be efficiently grained by the flowing energy of the atomized cutting fluid flowed from the common closed chamber into the cutting fluid feed passage and stably displaced to the tips of the tools. In addition, the flow rate of the cutting fluid jetted from the tips of the tools by supplying the normal cutting fluid can be broadly changed at a stroke.